Public Health
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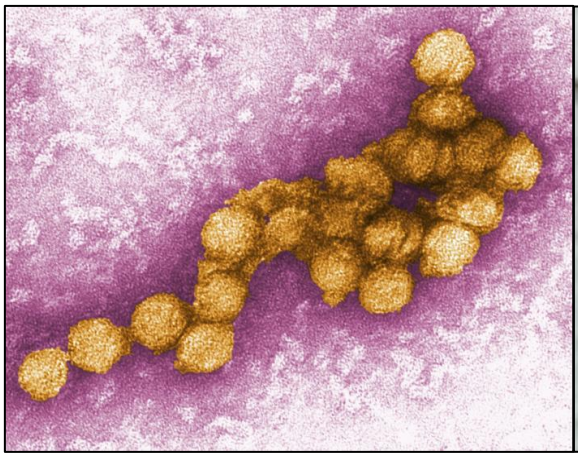
Shelby County Health Department

Shelby County
2011 West Nile Virus Report



Shelby County Health Department
Epidemiology Section and Vector Control Program
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Introduction

West Nile Virus (WNV), a disease that is transmitted to humans by mosquitoes, has caused many epidemics in the United States since it first appeared in 1999.[4] Efforts targeted at WNV prevention and control have been a priority for the Shelby County Health Department since 2002 when the first cases were identified among Shelby County residents. West Nile Virus has the potential to cause severe and even fatal illness. Currently there is no vaccine to prevent WNV and no medical cure; for patients who have severe disease, intensive supportive therapy is the only form of treatment. West Nile Virus was first detected in the bird population of Shelby County, Tennessee late in the season of 2001. The first human case occurred in September 2002, and there have been a total of 123 cases of WNV and 11deaths through 2011. In 2011, there were 12 WNV cases and two deaths in Shelby County. The majority of human cases of West Nile Virus within the state of Tennessee since 2002 have occurred in Shelby County.

Table 1. Human Cases of West Nile Virus and Deaths, Shelby County and State of Tennessee, 2002-2011

Year	Total Number of cases in Tennessee	Total Number of cases in Shelby County	Shelby County Fatalities
2002	56	40	7
2003	26	10	0
2004	14	12	0
2005	18	13	0
2006	22	14	0
2007	11	5	0
2008	19	10	1
2009	9	5	1
2010	4	2	0
2011	18	12	2
TOTAL	**197**	**123**	**11**

Case counts include both confirmed and probable cases as determined by the case definitions established by the Centers for Disease Control and Protection[8]

Clinical Information

West Nile Fever

The majority of people who are infected by a mosquito with West Nile Virus are asymptomatic. Those who do become symptomatic primarily show benign symptoms that are collectively referred to as West Nile Fever. This consists of fever, headache, and fatigue that may sometimes be accompanied by a skin rash, swollen lymph glands, and eye pain. The incubation period, which is the time period from being infected to developing symptoms, is thought to range from 2 to 14 days. For those who are immunocompromised, this time interval may be longer.[2]

Severe Neuroinvasive West Nile Virus Disease

When the central nervous system (CNS) is affected, this is referred to as neuroinvasive WNV. Clinical symptoms may range from febrile headache to aseptic meningitis and encephalitis. West Nile meningitis is characterized by the classical symptoms of meningitis (fever, headache and stiff neck) with possible lapses or loss of consciousness. West Nile poliomyelitis, a flaccid paralysis syndrome, is characterized by the acute onset of asymmetric limb weakness or paralysis. The most severe form of neuroinvasive West Nile viral disease is West Nile encephalitis, and involves severe symptoms like lethargy, confusion, and alteration of consciousness in addition to fever and headache.[2]

Clinical Suspicion and Laboratory diagnosis

WNV infection can be suspected in a person based on clinical symptoms and patient history.[2,8] Laboratory testing is required for a confirmed diagnosis (See Appendix B for more information on diagnosis) . Detailed travel history, date of onset of symptoms, vaccination, and knowledge of similar mosquito and tick-borne diseases need to be considered for people over the age of 50 who present with unexplained neuroinvasive symptoms like encephalitis or meningitis.[8] This is particularly true for Shelby County residents where year-round transmission is a possibility. Since no particular treatment for West Nile Virus is available, intensive supportive therapy is the only option to treat people who become severely ill.[3]

Risk Factors and Protective Strategies

The overall risk of contracting West Nile Virus is dependent on multiple factors. The majority of cases for both Shelby County and the rest of the country have occurred between the months of July and September. Though widely distributed throughout the country, the highest incidence rates are in the western and southern states.[1] Individuals who spend a lot of time outdoors, either occupationally or recreationally, have a greater chance of being bitten by an infected mosquito and contracting the disease.[1] The disease is also more severe in the elderly population greater than age 50 and those who are immunocompromised[1]. There is no person-to-person transmission of West Nile Virus; one develops the infection only after being bitten by an infected mosquito.[1]

Strategies that the public are encouraged to follow during West Nile Virus season include the following[1,11,12].

- Wear DEET-containing mosquito repellants or a repellant containing an EPA-registered active ingredient according to label directions. Shelby County residents are strongly encouraged to refrain from sitting outdoors at night; however, use repellents when outdoors, especially at night, regardless of perceived mosquito activity.
- Eliminate standing water where mosquitoes can lay eggs such as rain gutters. Check properties for objects - including old tires, flower pots and drip plates, tin cans, buckets, and children's toys - that collect rainwater and either drain or dispose of the water.
- Install or repair windows and door screens
- Empty, clean and refill birdbaths and small wading pools weekly
- Empty and refill pets' water bowls every few days
- Repair failed septic systems and leaky outside faucets
- Secure swimming pool covers tightly and store canoes, wheel barrows, and boats upside down.
- Stock ornamental lawn ponds with fish (Gambusia) that eat mosquito larvae (Gambusia fish are available FREE from the Vector Control Program)

Human Case Data

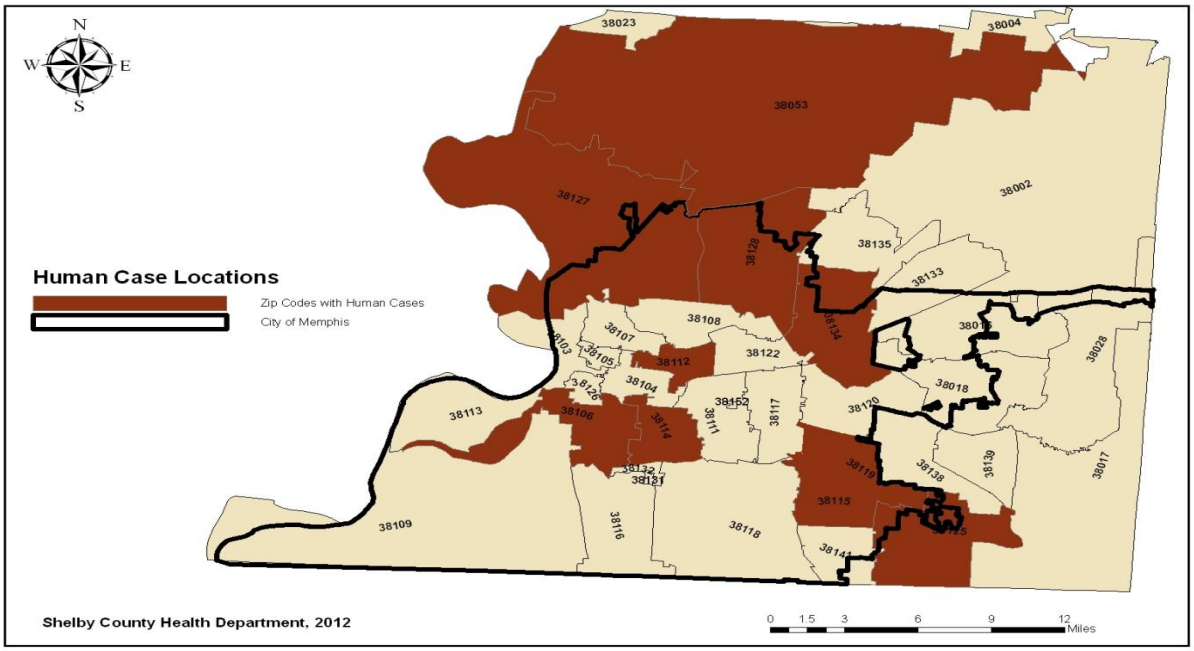
The 2011 season was a very active season for West Nile Virus in Shelby County compared to the previous season. For the entire season, there were a total of 12 cases (See Table 2) that were determined by the most recent standard criteria[8] set forth by the Centers for Disease Control and Prevention (CDC) (See Appendix A for CDC criteria). Of these 12 cases, eight were confirmed and four were probable. There were two fatalities among the confirmed cases that were both under the age of 50 and not immunocompromised with any significant past medical history. The first case expired in mid-September and the second case expired in early December. Seven of the cases were female and five were male. Nine of the cases were Neuroinvasive and three were Non-Neuroinvasive. The cases ranged in age from under 20 years old to over 80 years old, with most of the cases occurring in adults between 60-69 years old. The date of onset of the majority of cases was in the month of August, with two cases occurring in October, later than would be typically expected. Among three cases, travel outside of Shelby County may have contributed to infection. One of the fatalities had increased recreational risk with extended evening and nighttime yard work adjacent to a wooded area. Figure 1 shows the zip code locations where human cases of West Nile Virus resided in Shelby County during the 2011 season. It is important to note that the location of residence may not be the same as the location where a case was bit by an infected mosquito.

Table 2. Human Cases of West Nile Virus by Sex, Age, Race, Month of Onset, and Clinical Status, Shelby County, TN, 2011

Profile of Human WNV Cases, 2011	
	Number of Cases*
Total Number of Cases	12
Sex	
Male	5
Female	7
Age	
Less than age 50	4
Greater than age 50	8
Race	
Black	7
White	5
Month of Onset	
August	7
September	3
October	2
Clinical Status	
Neuroinvasive	9
Non-neuroinvasive	3

*Case counts include both confirmed and probable cases as determined the case definitions established by the Centers for Disease Control and Protection[8]

Figure 1: Zip Codes with Human Cases of West Nile Virus, Shelby County, TN, 2011



Mosquito Surveillance and Control Methods and Background

The transmission cycle of West Nile Virus involves birds as the reservoir for the virus and mosquitoes as vectors that transmit the disease. The principal vectors responsible for transmitting WNV in Shelby County are adult female mosquitoes of the *Culex species* that primarily rest during the day and bite humans and animals throughout the night. *Culex* mosquitoes tend to breed in stagnant water sources that range from artificial containers to large bodies of permanent water. These mosquitoes thrive in water that contains organic material which is common in urban areas with inadequate drainage and sanitation.[5]

Detection and control of WNV in mosquito populations are the primary tools that help health officials prevent human and domestic animal infections. Viral activity is currently monitored primarily through mosquito and human surveillance to pinpoint specific areas of high risk within Shelby County. The Health Department uses an integrated mosquito management program, which includes several components: (1) surveillance (monitoring levels of mosquito activity and where virus transmission is occurring), (2) source reduction of mosquito breeding sites, (3) use of chemical and biological methods to control mosquito larvae (larviciding), (4) use of chemical methods to control adult mosquitoes (adulticiding), and (4) community outreach and public education. Larvicides are products used to kill immature mosquitoes. If applied directly to water sources that hold mosquito eggs or larvae, the number of new mosquitoes can be limited. Adulticides are products used to kill adult mosquitoes. The ultimate goal of adulticiding is to reduce the number of mosquitoes that can bite people and possibly transmit WNV. Source reduction is the alteration or elimination of stagnant water sources that foster mosquito larval habitat breeding. It is the most cost-effective method that can include individual activities (proper tire disposal, cleaning bird baths, swimming pools and rain gutters) or water management projects by environmental agencies [3].

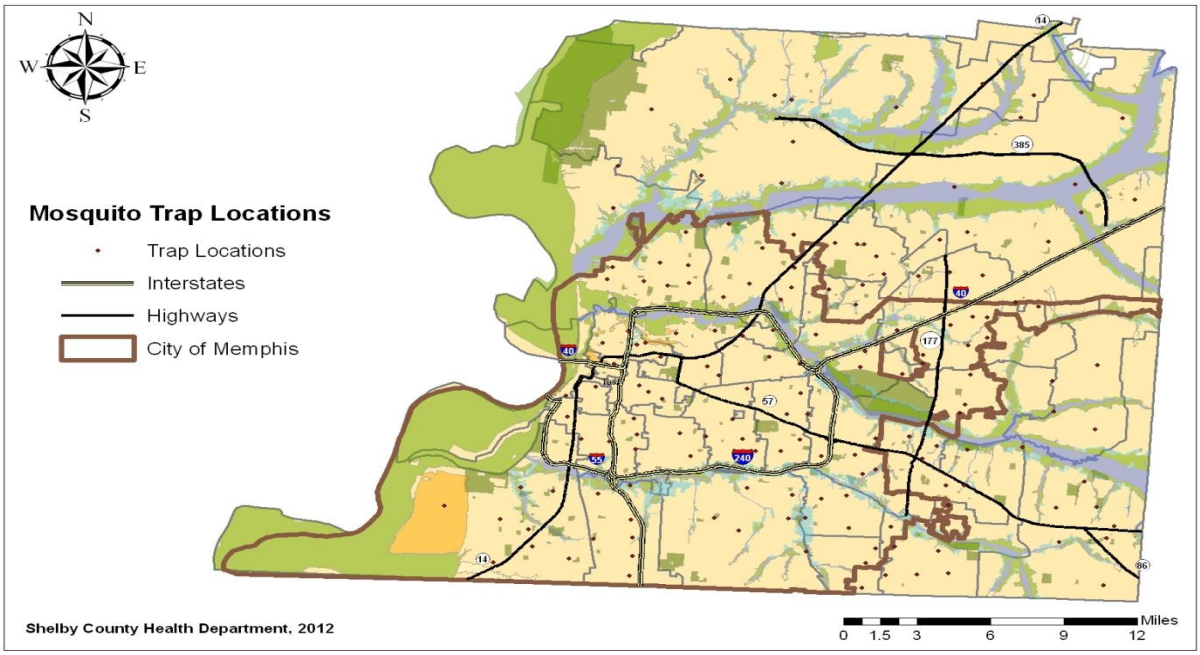
The Vector Control Program catalogs the locations of water producing mosquito larvae throughout Shelby County. Currently, there are approximately 3,000 sites. Larval sites are inspected from mid-March through the end of October, and information on the number and type of larvae is collected. The sites are classified as producing vector mosquitoes (mosquitoes that can transmit the virus) or nuisance mosquitoes. Vector sites may contain nuisance mosquitoes, but sites designated as nuisance sites do not contain vector mosquitoes. In 2011, there were approximately 750 nuisance sites and 2200 vector sites. The county is divided into 15 areas and a larviciding crew is assigned to each area. Depending on the time of year and surveillance information, crews are assigned to either a ‘nuisance site itinerary’ (inspecting all sites identified as producing nuisance mosquitoes) or a ‘vector site itinerary’ (inspecting all sites identified

as producing vector mosquitoes). The nuisance site itinerary will include vector sites that also produce nuisance mosquitoes. All sites on the assigned itinerary are inspected by a larviciding crew every two weeks and treated based on criteria called action thresholds (described later).

Adult vector mosquitoes are trapped from late-April to late-October and information is collected on type, number, and the presence of WNV-positive mosquitoes. WNV mosquito testing runs from May 1st to the end of October. The county is divided into 163 zones, sized based on the area an adulticide truck can treat in three hours. A gravid trap is placed in a centralized location in each zone. These traps are designed to collect adult female *Culex* mosquitoes preparing to lay their eggs. Each trap runs for 12 hrs overnight, typically once a week. Samples are sent to the State of Tennessee to be tested for West Nile Virus. The decision to adulticide a location is dependent on adulitciding action thresholds. Zones that do not meet the action threshold requirements will not be adulticided.

Action thresholds are established by Shelby County Health Department Division of Vector Control and then approved by Tennessee Department of Environment of Conservation under the authority of the United States Environmental Protection Agency. The action threshold for larval mosquitoes is based on the presence or absence of larval mosquitoes in a water sample taken using a standard 12 oz dipper. The action threshold for mosquito larvae and pupae is an average of one mosquito per dip per site.[12] The action threshold for adult vector mosquitoes is based on whether or not the vector mosquitoes have tested positively for a disease pathogen that can be a threat to human health. This includes West Nile Virus and a similar virus that causes St. Louis Encephalitis. When disease pathogens are detected the action threshold will be one mosquito per trap per night and when disease pathogens are not detected then the action threshold will be not lower than 50 mosquitoes per trap per night. When an action threshold is met or exceeded, adulticiding may be initiated. Zones are prioritized for adulticiding based on mosquito surveillance findings. Recent human case locations are also taken into account when prioritizing adulticiding schedules. Figure 2 shows the current mosquito trapping locations in Shelby County.

Figure 2. Mosquito Trapping Locations, Shelby County, TN, 2011



Abatement of West Nile Virus (WNV) relies in part upon the timing and targeting of control efforts to the particular phases and events of the outbreak as they occur. This requires mapping and calculating a number of statistics that depict the dynamics of an outbreak. The initial phase of a WNV outbreak involves the circulation of the virus in birds and mosquitoes. Infected blood-feeding mosquitoes pass the virus to birds, which in turn, develop sufficient levels of virus in their blood to lead to the infection of more blood-feeding mosquitoes. More and more birds and mosquitoes become involved in the cycle and the size of the area in which this is occurring gradually increases.

The general dynamics of each WNV outbreak are similar to one another; however, the exact location and the time that the virus will first occur and subsequently appear differs from year to year. As a precaution, Vector Control conducts larval inspection and treatment activities throughout the county before WNV activity begins. Larvae can develop from eggs deposited daily upon the water's surface. Vector Control larvicides the County on a schedule of once every two weeks. The larvicide's killing capability diminishes greatly after two weeks.

Larviciding is conducted from mid-March, when the first mosquitoes (*Aedes, Ochlerotatus* and *Psorophora* species) hatch from their winter eggs, until the end of October. The beginning of the season is devoted to larviciding nuisance sites containing *Aedes, Ochlerotatus,* and *Psorophora* species. This is the time of year when these species are most numerous.

Also prevalent in early spring is the *Culex restuans* species (white-spotted mosquito). This particular *Culex* species appears to be a poor vector of WNV because even when infected mosquitoes are identified, amplification or geographical expansion of the virus is not seen. White-spotted mosquitoes will naturally disappear; therefore, Shelby County does not engage in WNV vector control until house mosquitoes, *Culex quinquefasciatus* (northern house mosquito) and *Culex pipiens* (southern house mosquito), become plentiful. White-spotted mosquitoes are prevalent in the early spring, when house mosquitoes are absent. Gradually, as Memorial Day approaches, the number of white-spotted mosquitoes diminishes as they enter a state of dormancy during the summer. At the same time, house mosquitoes leave winter hibernation and begin to appear. Geographical expansion only occurs as the ratio of the house mosquito larvae (*Culex pipiens and Culex quinquefasciatus)* to white-spotted mosquito larvae (*Culex restuans*) increases. Vector Control tracks the ratio of white-spotted mosquito larvae to house mosquito larvae as a type of threshold to trigger larviciding vector mosquito sites.

May is the earliest month when mosquitoes can be sent for WNV testing. This schedule is set by the State of Tennessee. The first positive samples are usually detected at the same time that the transition of the *Culex* species occurs, typically around Memorial Day. Historically, the first positive locations have been in Memphis, Bartlett or Germantown. The virus is typically found much later in Collierville, Millington, Lakeland, Arlington and unincorporated Shelby County. Crews have begun to larvicide vector sites by the middle of May, at first detection of the virus, or when there has been an overwhelming prevalence of house mosquitoes.

Events surrounding an outbreak do not change the larviciding program. Weather however does have an influence. As sites dry in the summer, inspections become less necessary. The decision to cease inspection comes from the historical records of each site.

Adulticiding on the other hand is “shaped” by the dynamics of the outbreak. Disease foci are centers of amplification and are targeted for control in order to slow the expansion of the virus. Vector Control is required to extend this service to all localities in the county given that the service is paid for by all citizens through the Vector Control fee. The maximum number of zones that Vector Control can adulticide in one week is

40 zones, due to a limited amount of trucks and equipment. At times, the number of WNV positive zones will exceed 40 zones per week and adulticiding then is done on a rotational basis, which means each zone is adulticided about once a month. The entire county is sprayed at least two to four times per year at the rate of once per month.

While areas that have been identified as WNV disease foci are targeted for adulticiding, Vector Control does not specifically target areas for adulticiding based on vector mosquito densities. Densities often fluctuate week to week even without the effect of control. However, mosquito density can be an important factor in identifying areas that have had septic contamination. Sites are tracked by density groupings, e.g. 50-100, 100-500, over 500. Large numbers of house mosquitoes may be produced (e.g. 4,000-8,000 per trap night) if there is septic contamination of a creek or sewage outcropping. These areas will be larvicided and adulticided when necessary. The policy of the Health Department calls for public notification before spraying. These notifications are made through the media in the form of press releases and are posted on the Shelby County Website. Press releases are prepared weekly; therefore, spraying for high numbers may only be performed after a week of detection at the earliest.

Source reduction has been recently incorporated in larviciding operations for greater efficiency. Larviciding crews are charged with improving drainage as they conduct their inspections by removing trash and objects, such as used tires, that could generate mosquitoes. This work has only been performed during the winter months in past years. The crews have also been charged with making referrals to Health Department inspectors to have properties cleaned up if the accumulations of trash are greater than what they can remove in one or two trips. During the winter months, Health Department inspectors continue to actively locate tire piles for removal.

Mosquito Surveillance Data

Mosquito Density

Mosquito density, the mean number of mosquitoes per trap, is an important surveillance measure. Specifically, mosquito density helps Vector Control to focus their control efforts with respect to larviciding. It helps to identify sources or problem areas within the county where there are unusually high numbers of mosquitoes. As previously described, each week a gravid trap is placed in each of 163 zones for a 12-hour period; therefore, the mosquito density for each week reflects the mean number of mosquitoes collected per zone in a one night, 12-hr trap catch.

Figure 3 shows the mean number of *Culex* mosquitoes collected per trapping event for each of the past 5 years. Figure 4 shows a comparison of the mean number of Culex mosquitoes collected in 2011 by week vs. a 4-year mean of the previous years (2007-2010). Overall, the 2011 season did not have an unusually high number of mosquitoes. Figure 5 shows the geographic distribution of the mean mosquito density by zip code. Zip codes where human cases were located are outlined in blue. Most of the areas with the highest mosquito densities are within the city of Memphis.

Figure 3. *Culex* Species Mosquito Density by Year, Shelby County, TN, 2007-2011

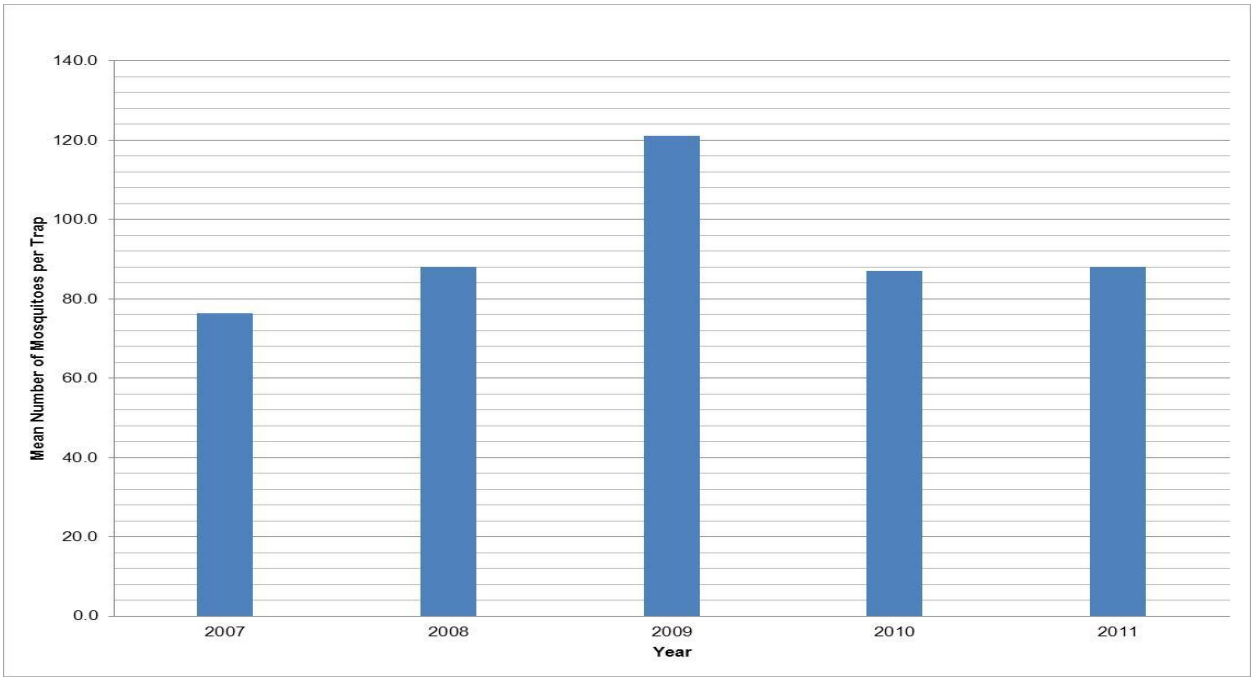


Figure 4. *Culex* Species Mosquito Density Comparison, 2011 vs. 4-year mean (2007- 2010), Shelby County, TN

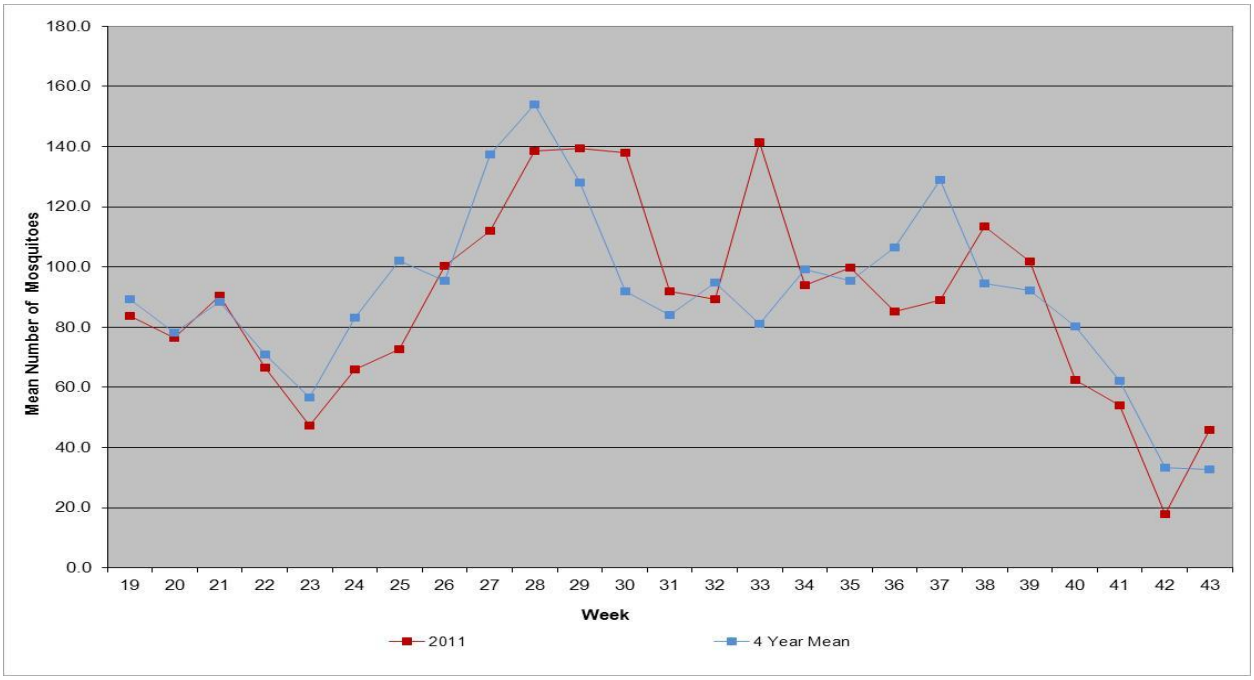
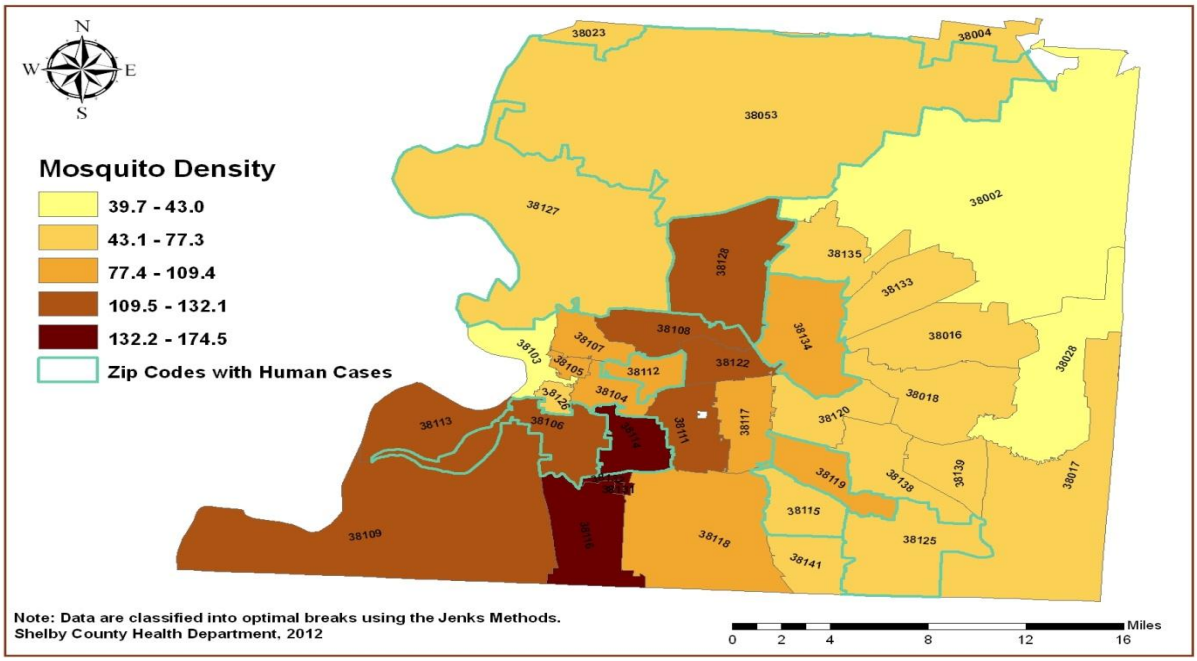


Figure 5. *Culex* Species Mean Mosquito Density by Zip Code, Shelby County, TN, 2011



WNV-Positive Mosquitoes and Persistent Positive Zones

When mosquitoes are sent to be tested for WNV, they are sent in groups that are collectively referred to as a mosquito 'pool'. In general, a mosquito pool can consist of up to 50 mosquitoes depending on how many mosquitoes are collected in the trap. For a mosquito pool to test positive, there only needs to be one WNV-positive mosquito in the pool. Thus, when a mosquito pool tests positive, it is not known how many of the mosquitoes in that pool are positive. For a trapping zone to be considered 'positive' for a specific week, there must be at least one WNV-positive pool from that zone.

Figure 6 shows the total number of positive pools by week comparing the 2011 season to the mean for the previous four years. It can be seen that the overall weekly number of positive pools for the 2011 season was much higher than the previous four-year mean (2007-2010) for most of the season and it peaked a couple weeks earlier. Figure 7 shows the total number of positive pools by zip code. Particularly high numbers of positive pools can be seen in the south-west and north-west of Shelby County as well as in some pockets in the eastern part of the county.

Figure 6, Number of Positive Pools by Week, 2011 vs 4-year mean (2007-2010)

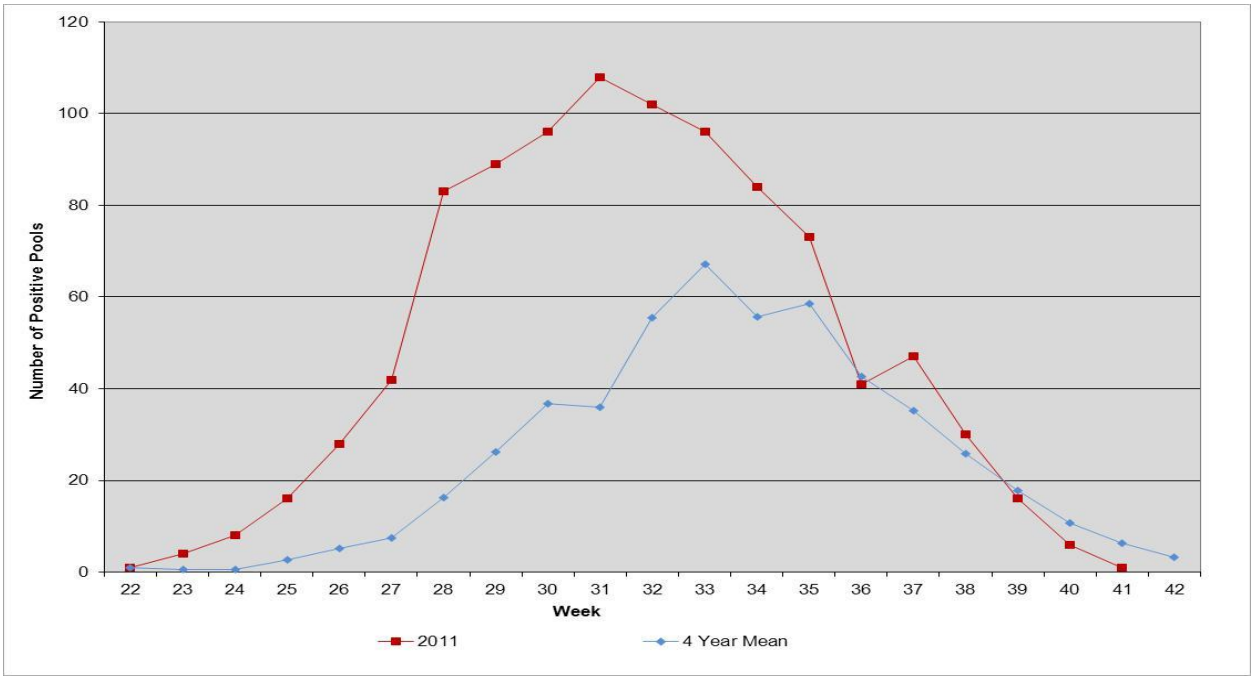
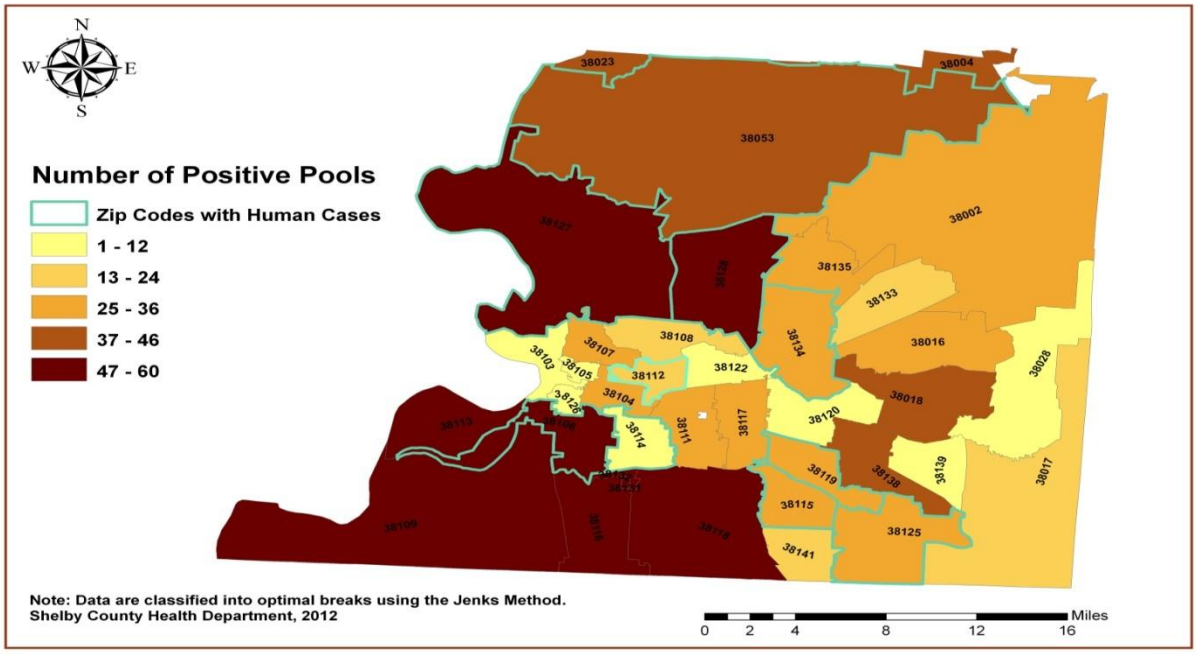


Figure 7. Total Number of Positive Pools by Zip Code, Shelby County, TN, 2011



West Nile Virus persistence is another measure utilized by the Vector Control section to target control measures. Persistence is measured as the number of weeks between when a zone first tests positive to the last week it tests positive.

Figure 8 shows the number of zones by their duration of viral persistence for the 2011 season compared to the mean for the previous four years (2007-2010). For example, in the 2011 season there were two zones that never tested positive for WNV (0 weeks of persistence) compared to a mean of about 22 zones in the previous four seasons, and in 2011 there were 21 zones that tested positive for 11 weeks compared to a mean of approximately six zones with this duration of persistence in the previous four seasons. In general, there were many more zones that had long durations of viral persistence in 2011 than there were in the previous four seasons.

Figure 9 depicts persistence by zip code, or the maximum number of consecutive weeks that any zone within a particular zip code has tested positive. Persistent positive areas can be detected diffusely throughout the county, though more concentrated in the northern areas.

Figure 8. Number of Zones by Duration of WNV Persistence, 2011 vs. 4-Year Mean (2007-2010)

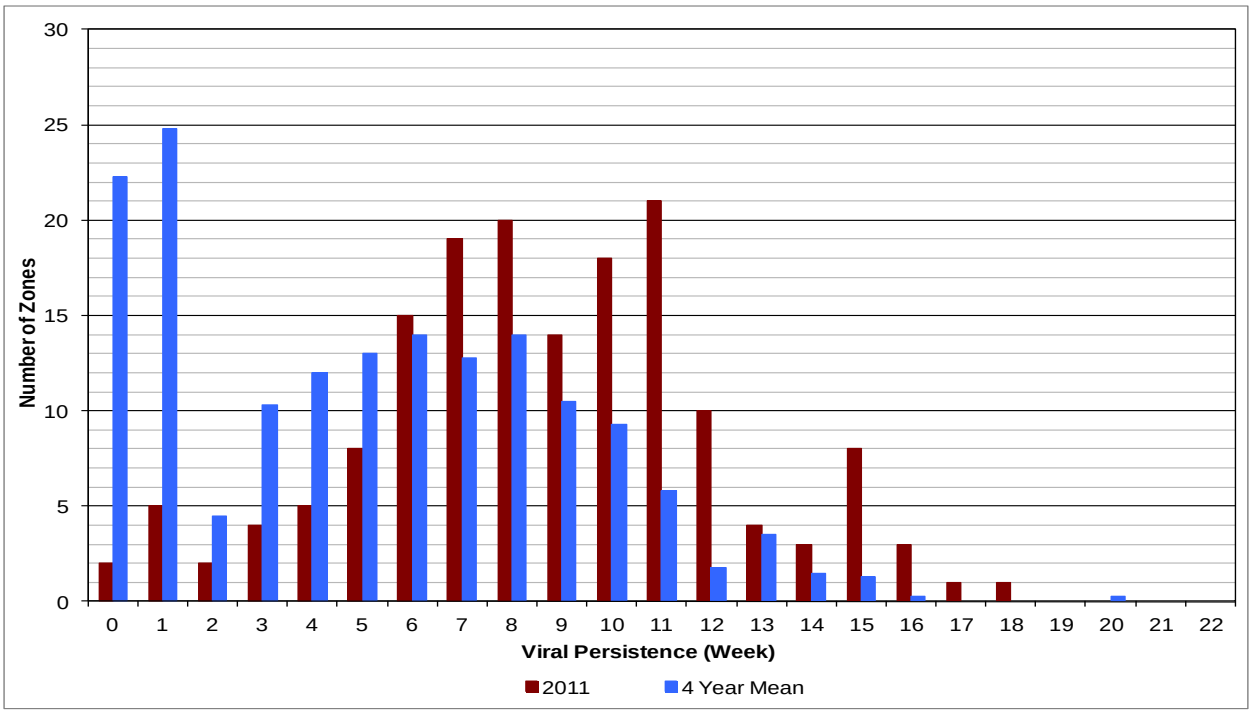
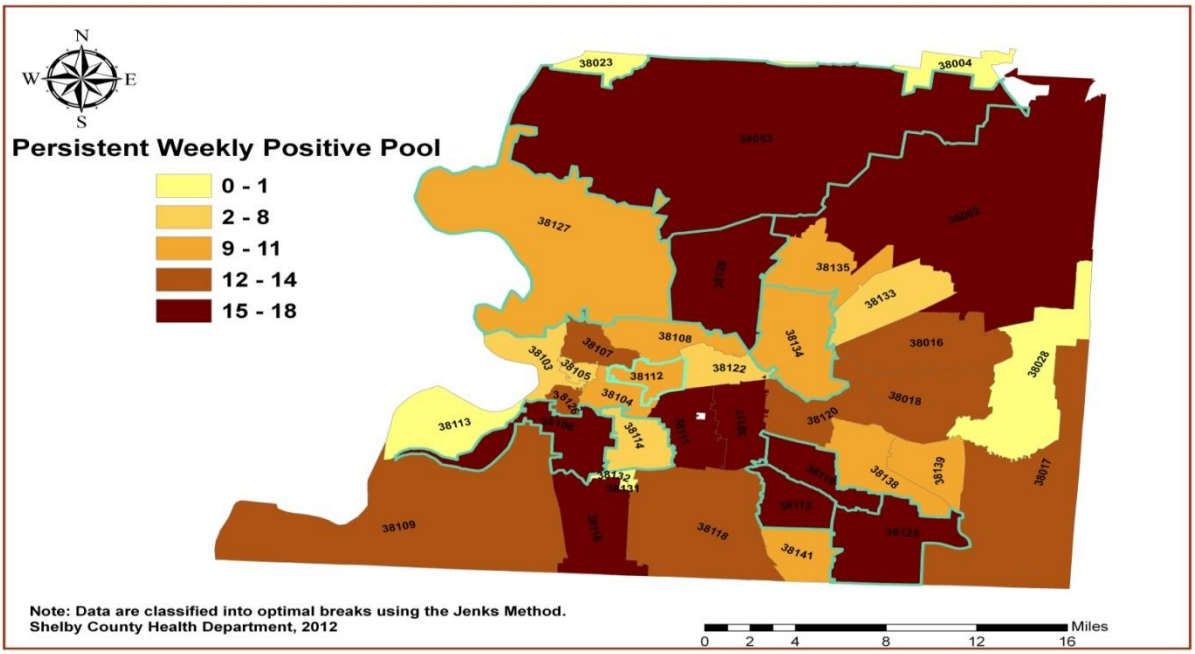


Figure 9. Maximum Number of Weeks of Persistent Positive Pools by Zip Code, 2011



Patterns and Conclusion

For the 2011 season, there were 12 total cases with two fatalities, compared with only two cases and no fatalities in 2010 and 5 cases and one fatality in 2009. It is interesting to note that both of the WNV fatalities in 2011 were under the age of 50. Overall, the increase in the number of human cases in 2011 coincides with higher numbers of positive pools earlier in the season and more zones with long durations of viral persistence compared to the previous four-year mean. It does not coincide with overall mosquito density data, where the 2009 season showed much higher mosquito density than other years. Additionally, although there was extensive flooding in 2011, the floods do not appear to have had a significant impact on WNV transmission. The mosquito densities for *Culex* species mosquitoes, which are the only species involved in WNV transmission, were similar in 2011 to the mean densities for the previous four years. There was, however, an increase in *Aedes vexans,* which are nuisance mosquitoes, shortly after the flooding reached its peak.

It is difficult to identify a clear pattern between the location of the human cases and mosquito surveillance data, particularly with regard to mosquito density and positive pools. Case locations appear to coincide to some extent with areas having persistent positive activity. The low virulence of West Nile Virus may contribute to a lack of detectable pattern. It is estimated that approximately 80% of individuals infected with WNV have no detectible symptoms or only mild symptoms that can be mistaken as a cold or the flu.[2] As a result, only the more severe cases are identified and reported. With a sample size of only about 20% of cases identified, a clear pattern may not be readily detectable.

Furthermore, there are numerous factors in addition to the presence of WNV-infected mosquitoes which can contribute to how each case became infected, including but not limited to: travel both within and outside the county, outdoor activity, use of insect repellants, screens on windows, other housing factors, population density, age, etc. Many of these factors likely vary with the economic status of communities. Human behaviors impact the rate at which people become infected. For example, there may be a high level of ‘risky behavior’ (i.e. being outdoors at dusk without using repellent) among people living in areas with low levels of West Nile Viral activity and relatively low levels of risky behavior in areas with high levels of West Nile Viral activity, or vice versa.

To ensure that future human cases of West Nile Virus are minimized, there are many factors that are used to target prevention and control measures given limited resources. Areas of the county where mosquitoes tend to breed are a definite focus of early mosquito control efforts. Vector Control larvicides throughout the county in anticipation

of the virus appearing anywhere within the county. Secondly, mosquito surveillance is conducted to both identify where viral activity is occurring and to adulticide the zones in which it is occurring, as well as the adjacent zones in an attempt to slow expansion and amplification. Zones with positive persistent mosquito pools collected for more than one week are monitored very closely. The locations of human cases are also considered. It is crucial to implement not only mosquito abatement efforts but public education measures as well. Citizens are encouraged to be vigilant as it relates to controlling mosquito populations around their homes and businesses, as well as to use personal protective measures to reduce their likelihood of becoming infected. The Shelby County Health Department will continue to take action during the West Nile Virus season to protect and inform our citizens.

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http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6127a3.htm

Appendix A

Arboviral Diseases, Neuroinvasive and Non-Neuroinvasive Case Definitions[8]

2011 Case Definition

(Replicated from http://www.cdc.gov/osels/ph_surveillance/nndss/casedef/arboviral_current.htm)

CSTE Position Statement Numbers: 10-ID-18, 10-ID-20, 10-ID-21, 10-ID-22, 10-ID-23, 10-ID-24

California Serogroup Viruses, (i.e., California encephalitis, Jamestown Canyon, Keystone, La Crosse, Snowshoe hare, and Trivittatus viruses)
Eastern Equine Encephalitis Virus
Powassan Virus
St. Louis Encephalitis Virus
West Nile Virus
Western Equine Encephalitis Virus

Background

Arthropod-borne viruses (arboviruses) are transmitted to humans primarily through the bites of infected mosquitoes, ticks, sand flies, or midges. Other modes of transmission for some arboviruses include blood transfusion, organ transplantation, perinatal transmission, consumption of unpasteurized dairy products, breast feeding, and laboratory exposures.

More than 130 arboviruses are known to cause human disease. Most arboviruses of public health importance belong to one of three virus genera: *Flavivirus*, *Alphavirus*, and *Bunyavirus*.

Clinical description

Most arboviral infections are asymptomatic. Clinical disease ranges from mild febrile illness to severe encephalitis. For the purposes of surveillance and reporting, based on their clinical presentation, arboviral disease cases are often categorized into two primary groups: neuroinvasive disease and non-neuroinvasive disease.

Neuroinvasive disease
Many arboviruses cause neuroinvasive disease such as aseptic meningitis, encephalitis, or acute flaccid paralysis (AFP). These illnesses are usually characterized by the acute onset of fever with stiff neck, altered mental status, seizures, limb weakness, cerebrospinal fluid (CSF) pleocytosis, or abnormal neuroimaging. AFP may result from anterior ("polio") myelitis, peripheral neuritis, or post-infectious peripheral demyelinating neuropathy (i.e., Guillain-Barré syndrome). Less common neurological manifestations, such as cranial nerve palsies, also occur.

Non-neuroinvasive disease

Most arboviruses are capable of causing an acute systemic febrile illness (e.g., West Nile fever) that may include headache, myalgias, arthralgias, rash, or gastrointestinal symptoms. Rarely, myocarditis, pancreatitis, hepatitis, or ocular manifestations such as chorioretinitis and iridocyclitis can occur.

Clinical criteria for diagnosis

A clinically compatible case of arboviral disease is defined as follows:

Neuroinvasive disease

- Fever (≥100.4°F or 38°C) as reported by the patient or a health-care provider, AND
- Meningitis, encephalitis, acute flaccid paralysis, or other acute signs of central or peripheral neurologic dysfunction, as documented by a physician, AND
- Absence of a more likely clinical explanation.
-

Non-neuroinvasive disease

- Fever (≥100.4°F or 38°C) as reported by the patient or a health-care provider, AND
- Absence of neuroinvasive disease, AND
- Absence of a more likely clinical explanation.

Laboratory criteria for diagnosis

- Isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid, OR
- Four-fold or greater change in virus-specific quantitative antibody titers in paired sera, OR
- Virus-specific IgM antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, OR
- Virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred, OR
- Virus-specific IgM antibodies in CSF or serum.

Case classification

Confirmed:
Neuroinvasive disease
A case that meets the above clinical criteria for neuroinvasive disease and one or more the following laboratory criteria for a confirmed case:

- Isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid, OR
- Four-fold or greater change in virus-specific quantitative antibody titers in paired sera, OR
- Virus-specific IgM antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, OR
- Virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred.

Non-neuroinvasive disease
A case that meets the above clinical criteria for non-neuroinvasive disease and one or more of the following laboratory criteria for a confirmed case:

- Isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid, OR
- Four-fold or greater change in virus-specific quantitative antibody titers in paired sera, OR
- Virus-specific IgM antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, OR
- Virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred.

Probable:
Neuroinvasive disease
A case that meets the above clinical criteria for neuroinvasive disease and the following laboratory criteria:

- Virus-specific IgM antibodies in CSF or serum but with no other testing.

Non-neuroinvasive disease
A case that meets the above clinical criteria for non-neuroinvasive disease and the laboratory criteria for a probable case:

- Virus-specific IgM antibodies in CSF or serum but with no other testing.

Comment

Interpreting arboviral laboratory results

- **Serologic cross-reactivity.** In some instances, arboviruses from the same genus produce cross-reactive antibodies. In geographic areas where two or more closely-related arboviruses occur, serologic testing for more than one virus may be needed and results compared to determine the specific causative virus. For example, such testing might be needed to distinguish antibodies resulting from infections within genera, e.g., flaviviruses such as West Nile, St. Louis encephalitis, Powassan, Dengue, or Japanese encephalitis viruses.
- **Rise and fall of IgM antibodies.** For most arboviral infections, IgM antibodies are generally first detectable at 3 to 8 days after onset of illness and persist for 30 to 90 days, but longer persistence has been documented (e.g, up to 500 days for West Nile virus). Serum collected within 8 days of illness onset may not have detectable IgM and testing should be repeated on a convalescent-phase sample to rule out arboviral infection in those with a compatible clinical syndrome.
- **Persistence of IgM antibodies.** Arboviral IgM antibodies may be detected in some patients months or years after their acute infection. Therefore, the presence of these virus-specific IgM antibodies may signify a past infection and be unrelated to the current acute illness. Finding virus-specific IgM antibodies in CSF or a fourfold or greater change in virus-specific antibody titers between acute- and convalescent-phase serum specimens provides additional laboratory evidence that the arbovirus was the likely cause of the patient's recent illness. Clinical and epidemiologic history also should be carefully considered.
- **Persistence of IgG and neutralizing antibodies.** Arboviral IgG and neutralizing antibodies can persist for many years following a symptomatic or asymptomatic infection. Therefore, the presence of these antibodies alone is only evidence of previous infection and clinically compatible cases with the presence of IgG, but not IgM, should be evaluated for other etiologic agents.
- **Arboviral serologic assays**. Assays for the detection of IgM and IgG antibodies commonly include enzyme-linked immunosorbent assay (ELISA), microsphere immunoassay (MIA), or immunofluorescence assay (IFA). These assays provide a presumptive diagnosis and should have confirmatory testing performed. Confirmatory testing involves the detection of arboviral-specific neutralizing antibodies utilizing assays such as plaque reduction neutralization test (PRNT).
- **Other information to consider.** Vaccination history, detailed travel history, date of onset of symptoms, and knowledge of potentially cross-reactive arboviruses known to circulate in the geographic area should be considered when interpreting results.

Imported arboviral diseases

Human disease cases due to Dengue or Yellow fever viruses are nationally notifiable to CDC using specific case definitions. However, many other exotic arboviruses (e.g., Chikungunya, Japanese encephalitis, Tick-borne encephalitis, Venezuelan equine encephalitis, and Rift Valley fever viruses) are important public health risks for the United States as competent vectors exist that could allow for sustained transmission upon establishment of imported arboviral pathogens. Health-care providers and public health officials should maintain a high index of clinical suspicion for cases of potentially exotic or unusual arboviral etiology, particularly in international travelers. If a suspected case occurs, it should be reported to the appropriate local/state health agencies and CDC .

Appendix B

Detailed Mosquito Surveillance Data Tables

Table B1. *Culex* Mosquito Density, Positive Pools, and Percent Positive by Week, Shelby County, TN, 2011

Week	Number of Mosquitoes Collected	Mean Number of *Culex* Mosquitoes per Trap	Number of Pools Tested	Number of Positive Pools	Percentage of Positive Pools
18	7390	71.1	127	0	0
19	11556	83.7	145	0	0
20	11336	76.3	145	0	0
21	12946	90.5	145	0	0
22	9195	66.6	145	0	0
23	7021	47.4	145	1	0.7
24	10017	65.9	145	4	2.8
25	11557	72.7	145	8	5.5
26	15555	100.4	145	16	11
27	17491	112.1	145	28	19.3
28	21734	138.4	145	42	29
29	22436	139.4	145	83	57.2
30	22082	138	145	90	62
31	14593	93	145	96	66.2
32	14377	89.3	145	108	74.5
33	22938	141.6	145	101	69.7
34	15330	94.1	145	97	66.9
35	16051	99.7	145	83	57.2
36	13714	85.2	145	75	51.7
37	14201	88.8	145	41	28.3
38	17807	113.4	145	47	32.4
39	16803	101.8	145	30	20.7
40	9939	62.5	145	16	11
41	8515	53.9	145	6	4.1
42	2760	17.7	145	1	1.8
43	7125	45.7	57	3	2.4

Table B2. Total Number of *Culex* Mosquitoes Collected, Mosquito Density, and Positive Pools by Zip Code, Shelby County, TN, 2011

Zip Code	Total Number of Mosquitoes Collected	Mosquito Density	Number of Positive Pools
38002	7,301	39.7	31
38016	11,165	57.1	36
38017	12,262	68.1	19
38018	8,224	54.3	41
38028	3,357	43	1
38053	16,224	64.2	46
38103	1,017	42.4	5
38104	9,561	95.9	29
38105	2,088	87	5
38106	16,902	117.2	51
38107	13,667	109.4	33
38108	12,559	126.9	24
38109	23,692	117.4	60
38111	15,354	124.7	35
38112	5,531	108.5	15
38114	8,519	170.4	11
38115	7,165	76.1	30
38116	30,400	174.5	53
38117	10,954	92.7	35
38118	16,987	99.2	52
38119	11,085	107.5	35
38120	1,730	69.2	11
38122	6,784	132.1	12
38125	9,680	58	28
38126	1,432	59.7	7
38127	19,177	77.3	54
38128	25,142	131.7	60
38133	5,750	59.3	19
38134	14,586	97.5	34
38135	8,232	57.1	36
38138	9,238	73.2	40
38139	2,905	57.3	7
38141	4,879	68.4	18

Table B3. Mean Number of *Culex* Mosquitoes per Week, Shelby County, TN, 2007-2011

Week	2007	2008	2009	2010	2011	4-Year Mean
19	64.9	124.0	123.7	44.7	83.7	89.3
20	39.6	86.8	73.7	112.5	76.3	78.2
21	76.8	93.8	97.3	85.9	90.5	88.5
22	54.0	105.8	85.1	39.1	66.6	71.0
23	54.2	43.7	73.5	55.0	47.4	56.6
24	139.1	46.5	72.2	74.5	65.9	83.1
25	138.1	63.9	113.6	92.8	72.7	102.1
26	92.6	67.0	87.0	134.5	100.4	95.3
27	77.4	158.6	164.5	149.4	112.1	137.5
28	73.8	93.5	210.6	237.7	138.4	153.9
29	82.9	129.8	236.7	62.6	139.4	128.0
30	60.0	103.1	106.8	97.2	138.0	91.8
31	53.4	81.1	127.9	73.3	92.0	83.9
32	81.7	73.6	152.9	71.1	89.4	94.8
33	45.3	73.7	137.2	68.2	141.6	81.1
34	53.3	89.5	191.5	62.5	94.0	99.2
35	66.3	101.6	147.4	66.1	99.7	95.4
36	80.6	87.3	151.2	106.6	85.2	106.4
37	73.6	152.3	171.2	118.1	88.9	128.8
38	94.1	66.4	92.0	126.1	113.4	94.7
39	100.1	98.6	74.9	95.2	101.8	92.2
40	66.4	81.5	121.7	51.5	62.5	80.3
41	88.6	51.9	43.1	65.3	53.9	62.2
42	--	86.8	--	46.1	17.7	33.2
43	--	38.8	50	42.1	45.7	32.7